

Concentration in Mathematics Education
for the Interdisciplinary Ph.D. Degree
Program in Curriculum and Instruction

Proposal approved by the Executive Committee of the Interdisciplinary
Ph.D. Degree Program in Curriculum and Instruction, and presented by

Dr. Marilyn P. Carlson, Department of Mathematics
Dr. Alfinio Flores, Curriculum & Instruction
Dr. Philip A. Leonard, Department of Mathematics
Dr. James A. Middleton, Curriculum & Instruction
Dr. Dennis L. Young, Department of Mathematics
Dr. Michelle J. Zandieh, Department of Mathematics

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Concentration in Mathematics Education for the Interdisciplinary Ph.D. Degree Program in Curriculum and Instruction

A. Description of current degree program and how the proposed concentration fits in

The Concentration in Mathematics Education would be an additional concentration area of the existing Interdisciplinary Ph.D. Degree Program in Curriculum and Instruction (IPDPCI). There are currently eleven concentration areas in this program, and the concentration in mathematics education would be the 12th. As such, the bylaws for the concentration in mathematics education will be the same as for the IPDPCI. Once approved, the concentration in mathematics education will have its own representation to the Executive Committee of the IPDPCI.

The courses and learning experiences in the current concentrations in the Interdisciplinary Ph. D. Degree Program in Curriculum and Instruction are divided into four areas: Core requirements, Professional Focus, Cognate Study, Dissertation and Individual Research. Each concentration requires a minimum of 90 - 93 semester hours beyond the bachelor's degree. The proposed concentration in mathematics education is also divided into the same four areas and requires a minimum of 90 semester areas beyond the bachelor's degree.

The structure of the new concentration follows exactly the same structure as the other concentrations. For mathematics education the core consists of six hours, the same core courses that are required for the other concentration areas. The professional focus includes at least 15 hours of inquiry and analysis, at least 27 hours of concentration in mathematics education and related areas, and at least 6 hours of internship. Like other concentration areas in the Ph. D. program in Curriculum and Instruction, the proposed concentration in Mathematics Education requires at least 12 hours of cognate study. The new concentration also requires at least 24 hours of independent research and dissertation.

Admission procedures are consistent with the other concentrations in the IPDPCI program. Students must submit evidence of an appropriate degree, transcripts, GRE scores, letters of recommendation, sample writing, a statement of interest and intent, and evidence of teaching experience, along with the application.

B. Need for proposed concentration in Mathematics Education

The proposed concentration is needed to satisfy both structural and theoretical demands of the field of mathematics education. Mathematics educators research issues of knowing, learning and teaching mathematics at the pre-kindergarten to university level; perform supervision of student teachers; develop curricular materials for K-16 students; prepare prospective and in-service teachers of K-12 mathematics; teach undergraduate mathematics; and teach graduate mathematics and mathematics education courses at institutions of higher education.

There is a currently a tremendous need for qualified people in this area, both at the state and national levels. In recent years, the numbers of positions open in mathematics education is greater than the number of doctoral students completing their program of study. Arizona State University is currently positioned to prepare professionals to work in these areas, and consequently contribute to responding to the existing shortages at the state and national levels.

Presently, Arizona State University does not offer a broad, comprehensive, and coordinated effort in mathematics education, although individual faculty members in both the department of mathematics and the college of education have experience and expertise in mathematics education research.

Collaboration between mathematics educators in the mathematics department and the college of education will benefit both groups. Faculty involved in this concentration have already collaborated by serving on doctoral committees and participating in joint grants such as ACCEPT. The concentration would provide an institutional framework to further promote this collaboration.

The concentration is interdisciplinary, involving faculty with different backgrounds to provide diverse perspectives to the experience of the concentration. This collaboration will enrich the research programs of the faculty involved in the concentration and provide a common focus for joint research and cooperation in the development of graduate courses in mathematics education.

A concentration in mathematics education would attract students from across the nation who have interest in studying in mathematics education. This would contribute to the research and scholarly culture of the faculty and the doctoral students in both the Department of Mathematics and the College of Education.

The concentration would provide ASU the opportunity to cover the entire spectrum (in conjunction with the other programs that are already established, see D) from early childhood, to upper elementary and middle grades, to secondary and college level mathematics education.

Graduates from the concentration in mathematics education will be hired by mathematics departments to perform research in mathematics education, prepare secondary teachers of mathematics, and teach graduate courses in mathematics education; by colleges of education, to perform research in mathematics education, prepare elementary and middle school teachers, and teach graduate courses in mathematics education; by institutions of higher education to prepare mathematics educators; by research and development organizations to participate in curriculum projects in mathematics; by school districts to do research and staff development in mathematics teaching and learning; and by institutions of higher education to prepare teachers. Typically, some of the students in a doctoral program in mathematics education are already faculty at local institutions of higher education. Completion of the proposed

program will prepare these teaching professionals to incorporate research into their activities.

C. A description of the unit's strengths in relation to the proposed concentration.

Arizona State University has a cadre of nationally recognized experts in mathematics education, housed either in the Division of Curriculum and Instruction or the Department of Mathematics. The major faculty involved in the concentration of mathematics education are

Dr. Marilyn P. Carlson	Assistant Professor, Department of Mathematics
Dr. Alfinio Flores	Professor, Curriculum & Instruction
Dr. Philip A. Leonard	Professor, Department of Mathematics
Dr. James A. Middleton	Associate Professor, Curriculum & Instruction
Dr. Dennis L. Young	Professor, Department of Mathematics
Dr. Michelle J. Zandieh	Assistant Professor, Department of Mathematics

The field of specialization of Drs. Flores and Middleton is mathematics education. They have their individual active programs of research and scholarly production in this field. In addition, they have collaborated in common projects and publications in the past. The proposed concentration would provide a structure to make their collaboration more systematic. The concentration would also facilitate attracting outstanding graduate students to participate in their research projects.

Dr. Carlson and Dr. Zandieh are faculty in the mathematics department and have an active research program in mathematics education at the college level. This concentration would broaden their research programs by allowing them to extend their influence to mathematics education for the secondary grades. Some of the research topics they currently study are also common to college and secondary mathematics. Dr. Leonard and Dr. Young are faculty in the mathematics department who have a high interest in mathematics education, expressed through their active involvement in issues related to this field.

The concentration would also provide a way to facilitate and institutionalize the collaboration between mathematics educators that are housed in the math department with those housed in curriculum and instruction. Five of the six major faculty have been approved to serve as chairs of dissertation committees. The major faculty are enough to provide a program in mathematics education at the same level of quality as other nationally recognized programs.

An additional benefit of the program is that it would provide highly qualified instructors for undergraduate methods courses, which would permit the major faculty to have a more balanced graduate-undergraduate teaching load, without sacrificing the quality of courses for prospective teachers.

Of the faculty who are mainly responsible for this concentration, Drs. Carlson, Flores,

and Middleton will initially be the faculty who will chair dissertation committees. Dr. Zandieh, as a new faculty member, would initially be part of the committees, and once she has established her research program, will also chair committees. Drs. Leonard and Young will also be part of the dissertation committees.

For faculty who are already mentoring doctoral students in other concentrations of the Interdisciplinary Ph. D. Degree Program in Curriculum and Instruction, the new students in mathematics education will replace students being mentored by them as they finish other concentrations. The faculty responsible for this concentration, together with the supporting faculty, forms a critical mass to offer doctoral students a stimulating research environment in mathematics education.

Other faculty in the College of Education and the Department of Mathematics will also provide support for the concentration. Dr. Knaupp is an experienced mathematics educator in Curriculum and Instruction. He is active in various programs and has developed a network of teachers, schools, and districts through direct involvement in the field. In addition, he has mentored doctoral students who have an interest in mathematics education.

Dr. Bitter, also in the College of Education, has an active program of funded research and development in educational media and computers, with a focus in mathematics education. The collaboration with Dr. Bitter is consistent with the emphasis on integration of technology in mathematics education, an interest also shared by the major mathematics education faculty in the college of education.

Dr. Kawski in the Department of Mathematics also has interest in mathematics education. He has attained national recognition by developing new approaches to the teaching mathematics using technology. He also supports this new concentration, and has served in the past on dissertation committees for students with a focus in mathematics education. Dr. Sharon Lohr from the statistics group in the mathematics department would also provide support and serve as dissertation committee member.

One special strength of the faculty involved in this concentration, is that their backgrounds and expertise permit a balanced program in terms of the distribution of mathematics and mathematics education courses between the Department of Mathematics and the Division of Curriculum and Instruction. In addition to the mathematics courses offered at the Department of Mathematics, courses rich in content in mathematics are taught by the mathematics educators at the College of Education. On the other hand, research courses in mathematics education are offered both at the Division of Curriculum and the Department of Mathematics.

D. Description of related ASU programs.

There are two existing doctoral programs at ASU that currently prepare students with an interest in mathematics education. One is the Ed. D. program at the College of Education,

where one of the areas is mathematics education. The other is the Ph. D. in mathematics in the Department of Mathematics. They are good choices for people interested in either end of a wide continuum. The new concentration would complement and share resources with these two programs, rather than duplicate and compete with them, as will be clear from the following discussion.

On one end of the spectrum the mathematics education option for the Ph.D. in the Department of Mathematics is intended to prepare students to do research in more mathematically advanced areas of undergraduate mathematics education. Consequently, preparation for this research will require a great deal of study of advanced mathematical topics. The student's interest and ability in mathematics will need to be sufficiently strong to compete mathematically with someone intending to do research in mathematics. This program requires a very strong background in mathematics, equivalent in terms of course work and comprehensive exams to that of the other Ph. D. students in mathematics.

The interdisciplinary program will appeal to students who also have a strong background in mathematics, but have mathematics education as their primary interest. Although a substantial amount of mathematics will be required for the program, the program offers a more balanced focus between mathematics and education coursework. The students applying for admission to this program will likely be individuals who have completed a master's in either mathematics or C&I, teaching faculty from community colleges, or talented school teachers from across the nation. Whereas, the students who pursue the mathematics research option in the Department of Mathematics will most likely be graduate students in mathematics who elect mathematics education as their research option. In conclusion, these programs compose a different mix of mathematics and mathematics education coursework, target different audiences and prepare students to conduct educational research on different mathematical levels.

One of the areas of the Ph. D. in Mathematics is research in college mathematics education Drs. Carlson and Zandieh are presently involved with this program, and they would continue to contribute to this program and also to the new concentration. Some of the courses presently offer in the Department of Mathematics for this program would be appropriate for students in the new concentration.

Another opportunity to share experiences between students in both programs and enrich their preparation is through the Preparing Future Faculty Program. This program is housed at ASU, and has other institutions of higher education as partners, including ASU-West, ASU-East, Grand Canyon University, and the Maricopa Community Colleges. This program would offer students in the new concentration the opportunity to interact with doctoral students pursuing a Ph. D. in mathematics and other areas, as well as with faculty in the participating institutions. This would potentially promote research collaborations with the faculty of these institutions.

On the other end of the spectrum, students with interest in mathematics education in the elementary grades can choose such option in the Ed. D. program in Elementary

Education. At present, faculty with expertise in mathematics education have been working with such students through this program, as well as related concentrations in the IDPDPCI, such as Elementary Education or Educational Media and Computers. The mathematics education faculty would continue to work with students in those concentrations who have a focus in mathematics education. Some of the courses of the new concentration in mathematics education would be of interest to those students. On the other hand, courses that are presently part of the concentrations of elementary education or educational media and computers with an emphasis in mathematics will also be of interest to students in the new concentration.

The proposed concentration of mathematics education is a natural extension to cover mathematics education for all grade levels in a coherent way. The main focus of this concentration will be for students who have an interest in pursuing research issues in middle grades mathematics, secondary mathematics, or college mathematics

E. Description of the degree requirements for this concentration.

A total of 90 semester hours are required for the program. At least 54 semester hours must be taken at ASU subsequent to the master's degree.

CORE REQUIREMENTS (total of 6 hours)

DCI 701 Curriculum Theory and Practice

DCI 791 Interdisciplinary Research Seminar

PROFESSIONAL FOCUS

Inquiry and analysis (at least 15 hours from the following)

COE 503 Introduction to qualitative research in education

EDP 552 Quantitative data analysis in education 1 (or equivalent)

EDP 554 Quantitative data analysis in education 2

EDP 556 Data processing techniques in measurement and research

EDP 651 Methods and practices of qualitative research

EDP 652 Multivariate procedures in data analysis 1

EDP 654 Multivariate procedures in data analysis 2

DCI 598 The teacher as a researcher

STP 530 Applied regression analysis

STP 531 Applied analysis of variance

STP 532 Applied nonparametric statistics

STP 533 Applied multivariate analysis

STP 534 Applied discrete data analysis

STP 535 Applied sampling methodology

QBA 527 Categorical data analysis

Other statistics / research methodology courses approved by program committee

Major area of concentration (at least 27 hours)

(At least 15 hours required from among the following)

EED 537 Mathematics in the elementary school (research based)
EED/SED 594 Mathematics in the middle school
EED 598 Children's mathematical thinking
MAT 598 Research in undergraduate mathematics education 1
MAT 598 Research in undergraduate mathematics education 2
MAT 598 Research in undergraduate mathematics education 3
MAT 598 Research in undergraduate mathematics education 4
EED/SED 791 Research in mathematics education 1
EED/SED 791 Research in mathematics education 2
EED/SED 791 Professional Publication

(At least 12 hours of electives, including 6 hours from the College of Education and 6 from the Department of Mathematics. Electives may be additional courses from the above list or courses from the following list.)

BLE 598 Teaching mathematics for Spanish speakers
EMC/EED 598 Technology in teaching and learning mathematics
EED/SED 598 Geometry for elementary and middle grades teachers
MTE 585 Modern geometry for teachers
MTE 583 Abstract algebra for teachers
MTE 587 Analysis for teachers
MTE 588 Analysis for teachers
EED 529 Science in the elementary school
SED/EED 594 Integrated mathematics, science, and technology
EED 581 Diagnosis and remediation in mathematics
EED 598 Special topics: The teaching of number and operations
EED/SED 598 Special topics: The teaching of geometry
SED 598 Special topics: The teaching of algebra
SED 598 Special topics: The teaching of calculus
EED/SED 598 Special topics: The teaching of probability
EED/SED 598 Special topics: The teaching of statistics
MAT 423 Numerical analysis 1
MAT 425 Numerical analysis 2
MAT 442 Advanced linear algebra
MAT 444 Intermediate abstract algebra
MAT 475 Differential equations
MAT 476 Partial differential equations
MAT 472 Intermediate real analysis
MAT 445 Theory of numbers
MAT 494 Scientific computing
MAT 454 Introduction to Chaos

MAT 570 Real analysis
STP 421 Probability
STP 427 Mathematical Statistics
MAT 543 Abstract algebra
Other electives approved by program committee

Internship (6 hours)

EED/SED 784 Internship in teaching mathematics
EED/SED 784 Internship in research in mathematics education
MAT 784 Internship in teaching undergraduate mathematics

COGNATE STUDY (at least 12 hours)

To broaden their understanding of the conceptual base and issues underlying the study of curriculum and instruction, students take related work outside mathematics education. Students are expected to choose courses that have a clear link to their dissertation efforts. Students who need to deepen their understanding of the conceptual bases of mathematics education, may take related courses in mathematics, statistics, or related fields. Courses for cognate study are selected in consultation with the student's program committee.

DISSERTATION AND INDEPENDENT RESEARCH (a total of 24 hours)

EED/SED 792 Research
EED/SED 799 Dissertation

Other requirements

The mathematical background of students in this concentration should be well beyond the grade band that they are interested in pursuing. For the three different levels of interest, namely, college mathematics, secondary mathematics, and middle grades mathematics, the following are the requirements. A person interested in college level mathematics education should have the equivalent of a master's degree in mathematics or a related field at the time of applying. For secondary mathematics education, the equivalent of a major in mathematics or a related field to enter, and take some graduate level courses in mathematics as part of their program. For the middle grades, a person needs at least one year of calculus, and a transition course to advanced mathematics, equivalent to MAT 300 Mathematical structures. In extraordinary cases, K - 8 certified teachers with strong potential in mathematics who do not have the transition course may be admitted, but will have to take it during their first year of their studies.

Residency

The student must spend at least two consecutive semesters (not including summer sessions) as a full time student at Arizona State University.

Comprehensive examination (written and oral defense)
Dissertation proposal (written and oral presentation)

Dissertation (written and oral defense)

The dissertation will prepare the candidate to perform independent research at the level of scholarship required by the profession.

Although several of the courses are currently listed using the omnibus number 598, most are courses that have been offered. In addition, several will be given a 700 level number to reflect that the courses are doctoral level.

F. The administration of the new concentration

The new concentration will be part of the Interdisciplinary Ph. D. Degree Program in Curriculum and Instruction. It will have the same governance structure as the other concentrations. A faculty member of mathematics education concentration will be elected by the other faculty in this concentration to represent it in the Executive Committee.

Students can be admitted the semester after the concentration is approved. The number of students will be limited to the number that major faculty in mathematics education can mentor. Most of the courses for this program are already being offered by the university. The two research seminars in mathematics education will be developed jointly by Drs. Flores and Middleton, with the input of the other major faculty in the program. These course will be taught by the faculty on a rotating basis. The special topics courses will be developed as the need arises.

The budgetary implications of this new concentration are minimal. There is no need to hire additional faculty for this program. Doctoral students can participate directly in funded research projects conducted by the faculty in this concentration. Support for students would be provided through graduate assistantships, associated to grants of the faculty involved in this concentration. Doctoral students in their second year in the program can teach the undergraduate methods courses in Curriculum and Instruction. Depending on their background, doctoral students can also teach undergraduate courses in mathematics. At present, both the Department of Mathematics and the Division of Curriculum and Instruction use non-permanent faculty associates and graduate students to teach such courses, and the students in the doctoral program would be highly competitive for these positions.

With respect to books, the university library has an adequate collection in mathematics education. The University already carries the major journals in mathematics education. The library has been very receptive in the past for suggestions of books acquisitions, and the collection can be kept up-to-date. With respect to curriculum materials, the Science/Social Studies/Mathematics lab in Curriculum and Instruction has a basic collection. The College of Education also has site licenses for most of the exemplary computer and other technology programs for mathematics education. The collection can be up-dated on a yearly basis.

There is no need for additional space. The College of Education and the Department of Mathematics have the necessary space for class and laboratories.

There is no need for additional personnel specific for this concentration. Students will be recruited through the personnel presently assigned to the doctoral program.

G. Vitae of faculty members who are mainly responsible for the concentration in mathematics education follow.

CURRICULUM VITAE

Marilyn P. Carlson, Assistant Professor
Department of Mathematics
Arizona State University

Education

Ph.D. in Mathematics Education (July, 1995)

University of Kansas, Lawrence, KS

Dissertation: "A Cross-Sectional Investigation of the Development of the Function Concept".

Current Position

Assistant professor, Department of Mathematics, Arizona State University.

Publications

Carlson, M. (1998). "The Mathematical Behavior of Successful Mathematics Graduate Students: Influences Leading to Mathematical Success"; Education Studies in Mathematics.

Carlson, M.; Buskirk, T. (1998). "Assessing College Students' Views About Mathematics with the Views About Mathematics Survey"; under review, 30 pages.

Carlson, M. (1998). "Notation and Language: Obstacles for Undergraduate Students' Concept Development"; Psychology of Mathematics Education: North America, Conference Proceedings.

Carlson, M. (1998). "A Cross-Sectional Investigation of the Development of the Function Concept"; Research in Collegiate Mathematics Education. III, pp. 114-163.

Carlson, M. (1997). "Obstacles for College Algebra Students in Understanding Functions: What Do High Performing Students Really Know?"; AMATYC Review.

Carlson, M. (1997). "The Development of an Instrument to Assess Students' Views About the Methods and Learnability of Mathematics"; Psychology of Mathematics Education: North America, Conference Proceedings.

Carlson, M. (1994). "A Successful Transition to a Calculator Integrated Precalculus Curriculum: Clues, Surveys & Trends"; International Conference on Technology in Collegiate Mathematics Conference Proceedings; Fall, 1994.

Carlson, M. (1988). "A Design and Implementation of a Mathematics Test Generator"; National Education Computing Conference Proceedings; July, 1988.

Minor Publications:

Carlson, M. (1996). "Reform Efforts in Mathematics Result in New Curricula and Enhanced Faculty Cooperation"; Arizona Collaborative for the Preparation of Teachers, Volume 1.

Carlson, M. (1996). "What Do High Performing College Algebra Students Know About Functions?"; AMS/MAA Conference Proceedings; January, 1996.

Carlson, M. (1995). "A Longitudinal Investigation of the Development of the Function Concept"; AMS/MAA Conference Proceedings; January, 1995.

Select Presentations

"The Mathematical Behavior of Successful Mathematics Graduate Students: Influences Leading to Mathematical Success"; RUME (Research in Undergraduate Mathematics Education) Conference (Sept. 1998).

"Undergraduate Mathematics Education Graduate Programs"; RUME (Research in Undergraduate Mathematics Education) Conference (invited panel discussion, Sept. 1998).

"Notation and Language: Obstacles for Undergraduate Students' Concept Development"; Psychology of Mathematics Education: North America, Conference Proceedings (Oct., 1998).

"Developing High School Students' Understanding of Function: Recommendations Based on Research"; 76th Annual Meeting of the National Council of Teachers of Mathematics, (Washington D.C., April, 1998).

"A Longitudinal Investigation of the Function Concept"; RUME (Research in Undergraduate Mathematics Education) Conference; Sept., 1996. (refereed general session).

"Views About Mathematics Survey"; RUME (Research in Undergraduate Mathematics Education) Conference; Sept., 1996.

"Evaluating New Curricula"; The Fifth Conference on the Teaching of Mathematics, Baltimore, Maryland; June, 1996 (invited presentation).

"What Do High Performing College Algebra Students Know About Functions?"; Maricopa Math Chairs Retreat (invited presentation); June, 1996.

"An Update of First Year Mathematics at Arizona State University"; 1996 Joint Spring Meeting (State); Flagstaff, AZ; April, 1996.

"What Do High Performing College Algebra Students Know About Functions?"; AMS/MAA Conference; January, 1996.

Grants

PI: A Redefinition and Reform of Preservice Secondary Mathematics Curriculum.
Funding Agency: Eisenhower; \$49,500.

PI: Undergraduate Mathematics for Elementary Teachers: A Collaborative Reform.
Funding Agency: Eisenhower; amount awarded; \$42,000.

Co-PI: ACEPT grant (Arizona Collaborative for the Excellence in the Preparation of Teachers). Funding Agency: NSF.

Co-PI: Changing the High School System: Implementing the Interactive Math Project in Arizona. Funding Agency: NSF.

Co-PI: Maricopa Mathematics Consortium: Advanced Technological Education Project.
Funding Agency: NSF.

Recent Curriculum Development Activities

Developed two new graduate courses in research in undergraduate mathematics education.

Directed workshop for revising preservice secondary curriculum; summer, 1998.

Directed numerous ACEPT related curriculum development activities for first year mathematics at ASU; 1995-1998.

Abbreviated Vita

Alfinio Flores

Present position: Professor, Curriculum & Instruction, Arizona State University

Education

1985	Ohio State University.	Ph. D. Mathematics Education
1978	National University of Mexico	M. Sc. Mathematics
1976	National University of Mexico	B. Sc. Mathematics

Work experience

1998 -	Professor, Arizona State University
1992 - 1998	Associate Professor, Arizona State University
1989 - 1992	Associate Professor, San Diego State University
1984 - 1989	Associate Researcher, Centro de Investigación en Matemáticas
1982 - 1984	Teaching Associate, Ohio State University
1980 - 1982	Research Assistant, Centro de Investigación en Matemáticas

1978 - 1980 Curriculum Development (Mathematics), Ministry of Education of Mexico

Funded projects

Flores, A. & Bitter, G. (1994). Preparing teachers for leadership in technology. Funded by Arizona Board of Regents - Eisenhower Mathematics & Science Education Act and Arizona State University.

Flores, Alfinio. (1987). Manipulative materials for the teaching of mathematics: 15 laboratory activities for grades 7-9. Funded by the State Department of Education of Guanajuato.

Flores, Alfinio. (1986). Mathematics laboratory and the computer in the teaching of junior high school mathematics. Funded by the State Department of Education of Guanajuato.

Flores, Alfinio. (1985 -1986). Mathematics laboratory: 40 activities for high school. Funded by the Ministry of Education of Mexico.

Selected publications

Flores, A. (Accepted). The law of cosines: Connections for future teachers. PRIMUS.

Flores, A. (1998). The kinematic method and the Geometer's Sketchpad in geometrical problems. *International Journal of Computers for Mathematical Learning*, 3, 1-12.

Flores, A. (1998). Mean machines. *Mathematics Teacher*, 91, 266-268.

Flores, A. & Birge, L. (1998). Ancestry of humans and bees. *School Science and Mathematics*, 98, 99-103.

Flores, A. (1997). Sí se puede. It can be done: Quality mathematics in more than one language. In J. Tentacosta (Ed.), *Multicultural and gender equity in the mathematics classroom* (p. 81-91). Reston, VA: National Council of Teachers of Mathematics.

Flores, A. (1997). Curves as envelopes with the Geometer's Sketchpad. *Mathematics and Computer Education*, 31(1), 56-65.

Flores Peñafiel, A. (1997). Soluciones geométricas a problemas de máximos y mínimos. *Miscelánea Matemática*, 26, 49-57.

Flores, A. & Guest, A. (1997). Fibonacci in the forest. *School Science and Mathematics*, 97, 388-392.

Flores Peñafiel, A. (1996). Acción, comunicación, y reflexión: Componentes esenciales para entender matemáticas. In M. Santos and E. Sánchez (Eds.) *Perspectivas en educación matemática* (p. 85-102). México: Grupo Editorial Iberoamérica.

Flores, A. & Perkins, I. (1996) Tin-can ice cream. *School Science and Mathematics*, 96, 46-49.

Flores, A. (1995). Bilingual lessons in early-grades geometry. *Teaching Children Mathematics*, 1(7), 420 - 424.

Flores, A. (1995). Explorando funciones con una calculadora gráfica. *Educación Matemática*, 7(1), 125-133.

Flores, A., Sowder, J. T., Philipp, R., & Schappelle, B. (1995). Orchestrating, promoting, and enhancing mathematical discourse in the middle school: A case study. In J. T. Sowder (Ed.) *Providing a foundation for teaching middle school mathematics* (p. 275-299). Albany, NY: State University of New York Press.

Flores, A. (1995). Connections in proportional reasoning: Levers, arithmetic means,

mixtures, batting averages, and speeds. *School Science and Mathematics*, 95, 423-430.
 Flores, A. (1994). Geometry of numeric iterations. *PRIMUS*, 4(1), 29-38.
 Philipp, R., Flores, A., Sowder, J. & Schappelle, B. (1994). Conceptions and practices of extraordinary mathematics teachers. *Journal of Mathematical Behavior*, 13, 155 - 180.
 Flores, A. (1993). Connections: A lottery, a computer and the number e. *Mathematics Teacher*, 86, 652-655.
 Flores, A. (1993). Pythagoras meets Van Hiele. *School Science and Mathematics*, 93, 152-157.
 Flores, A. (1992). Geometric sequences, squaring, and square roots. Three approaches to the golden ratio. In *Calculators in Mathematics Education* (p. 241-244). Reston, VA: National Council of Teachers of Mathematics.
 Flores, A. (1992). Mathematical connections with a spirograph. *Mathematics Teacher*, 85, 129-137.
 Flores, A. (1991). Calculators in calculus: That's the limit. *PRIMUS*, 1(3), 295 - 301.
 Reys, B. J.; Reys, R. E.; Flores, A. (1991). Estimation Performance and Strategy Use of Mexican 5th and 8th Grade Sample. *Educational Studies in Mathematics*, 22, 353-375.
 Flores, A. & McLeod, D. (1990). Calculus for middle school teachers using computers and graphing calculators. In *Proceedings Third Annual International Conference on Technology in Collegiate Mathematics*. Columbus, Ohio: The Ohio State University.
 Flores, A. (1988). Computer-Calculated Roots of Polynomials. In A. Coxford (Ed.), *The Ideas of Algebra* (p.164-169). Reston, VA: National Council of Teachers of Mathematics.
 Flores, A. (1985). Parabella. *Mathematics Teacher*, 78, 30 - 33.
 Flores, A. (1984). A microcomputer and the law of small numbers. *Arithmetic Teacher*, 31(7) 60-61.

Presentations (Selection):

1997 Sí se puede. It can be done: Quality mathematics in two languages. NCTM Annual Meeting, Minneapolis, MN.
 1996 A science/mathematics classroom/laboratory for authentic integration of technology. NSTA Western Area, Phoenix, AZ (with Staley, Middleton, & Knaupp)
 1994 Hands on geometry. NCTM Regional Meeting, Phoenix, AZ.
 1992 Exploration of iterative processes and functions with a graphing calculator. 7th International congress on Mathematical Education. Québec, Canada
 1990 Research in computational estimation (with Reys, Reys, and Yoshikawa).
 Research
 Pre-session NCTM Annual Meeting, Salt Lake City, Utah.
 1989 The effect of programming on the learning of calculus concepts. NCTM Annual Meeting, Orlando, Fla.
 1986 Using computers to teach better mathematics. NCTM Annual Meeting, Washington

Others

Editorial Committee, *Eureka* (1998-), *Educación Matemática* (1988-89). Vice-president *Asociación Nacional de Profesores de Matemáticas* (1987-1989). Referee: *Teaching*

Children Mathematics, School Science and Mathematics, Educación Matemática, Journal for Research in Mathematics Education.

VITA

James A. Middleton, Ph.D.
Arizona State University

Education:

Ph.D. University of Wisconsin, Madison 1990-1992, Educational Psychology
M.S. University of Wisconsin, Madison 1988-1990, Educational Psychology
B.A. California State University, Chico, 1984-1987, Honors Psychology

Work:

1998 - Present Associate Professor of Mathematics Education, Division of Curriculum and Instruction, Arizona State University.

1994 - 1998 Assistant Professor of Mathematics Education, Division of Curriculum and Instruction, Arizona State University

1991-1994 Assistant Researcher, National Center for Research in Mathematical Sciences Education, University of Wisconsin Madison. Postdoctoral position.

1991 Associate Lecturer, University of Wisconsin Madison, Educational Psychology.

1988-1991 Research Assistant, Wisconsin Center for Education Research.

Current Funded Projects:

Co-PI, Cognitively Guided Instruction/ Director of Research Component. Three-year (Fall, 1996-Fall, 1999), \$1 million National Science Foundation project.

Technology Coordinator for the TEAMS project, the College of Education component of the Arizona Collaborative for the Educational Preparation of Teachers, a 5 million dollar project sponsored by the National Science Foundation.

Journal Articles:

Clasen, D. R., Middleton, J. A., & Connell, T. J. (1994). Assessing artistic and problem-solving performance in minority and nonminority students using a nontraditional multidimensional approach. *The Gifted Child Quarterly*, 38(1), 27-32.

Meyer, M. R., Delagardelle, M., & Middleton, J. A. (1996). Addressing Parents' Concerns Over Curriculum Reform. *Educational Leadership*, 53(7), 54-57.

Middleton, J. A. (in press). Curricular influences on the motivational beliefs and practice of two middle school mathematics teachers: A follow-up study. Manuscript accepted for publication in *Journal for Research in Mathematics Education*.

Middleton, J. A. (1995). A Study of Intrinsic Motivation in the Mathematics Classroom: A Personal Constructs Approach. *Journal for Research in Mathematics Education*, 26(3), 254-279.

Middleton, J. A., Flores, A., & Knaupp, J. (1997). Shopping for Technology

Educational Leadership, 55(3), 20-23.

Middleton, J. A., & Roodhardt, A. (1997). Using knowledge of story schemas to structure mathematical activity. *Current Issues in Middle Level Education*, 6(1), 40-55.

Middleton, J. A., & Spanias, P. (in press). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the recent research. *Journal for Research in Mathematics Education*.

Middleton, J. A., & van den Heuvel-Panhuizen, M. (1995). The Ratio Table: Helping Students Understand Rational Number. *Mathematics Teaching in the Middle School*, 1(4), 282-288.

Middleton, J. A., van den Heuvel-Panhuizen, M., & Shew, J. A. (1998). Using bar representations as models for connecting concepts of rational number. *Mathematics Teaching in the Middle School*, 3(4), 302-312.

Middleton, J. A., Littlefield, J., & Lehrer, R. (1992). Gifted students' conceptions of academic fun: An examination of a critical construct for gifted education. *The Gifted Child Quarterly*, 36(1), pp. 38-44.

Piburn, M. D., & Middleton, J. A. (in press). Patterns of faculty and student conversation in listserv and traditional journals in a program for pre-service mathematics and science teachers. Manuscript accepted for publication in *Journal of Research on Computing in Education*.

Van den Heuvel-Panhuizen, M., Middleton, J. A., & Streefland, L. (1995). Student-generated problems: Easy and difficult problems on percentage. *For the Learning of Mathematics*, 15(3), 21-27.

Books:

Middleton, J. A., & Goepfert, P. (1996). *Inventive Strategies for Teaching Mathematics: Implementing Standards for Reform*. Washington, DC: American Psychological Association.

Chapters in Edited Volumes:

Middleton, J. A., & Corbett, R. (in press). The Development of Students' Thinking About Structure and Geometry. To appear in R. Lehrer & D. Chazan (Eds.), *New Directions in Teaching and Learning Geometry*. Hillsdale, NJ: Lawrence Erlbaum.

Middleton, J. A., Smith, Stephanie Z., Romberg, T. A., & Smith, Marvin E. (in press). What to teach next year in seventh grade mathematics. In *What's a Teacher to Do? New Curricula for New Standards*. National Alliance for Restructuring Education.

Middleton, J. A., & Webb, N. L. (1994). Collaboration and Urban School Systems. In N. L. Webb and T. A., Romberg (Eds.), *Reforming Mathematics Education in America's Cities*, (pp. 105-128). New York: Teachers' College Press.

Romberg, T. A., & Middleton, J. A. (1994). *Conceptions of Mathematics and*

Mathematics Education Held by Teachers. In N. L. Webb and T. A. Romberg (Eds.), *Reforming Mathematics Education in America's Cities*, (pp. pp. 83-104)). New York: Teachers' College Press.

Meyer, M. R., & Middleton, J. A. (1993) *Affect and Motivation in Secondary Mathematics*. In A. E. Woolfolk (Ed.), *Readings and Cases in Educational Psychology*. Needham Heights, MA: Allyn & Bacon.

Clasen, D. R., & Middleton, J. A. (1991). *Identifying gifted minority students: An analysis of the Project STREAM talent assessment model*. In N. Colangelo, S. G. Assouline, & D. L. Ambrosion (Eds.), *Talent Development: Proceedings from the 1991 Henry B. and Jocelyn Wallace National Research Symposium on Talent Development*. Unionville, NY: Trillium Press.

VITA

NAME: Dennis L. Young

EDUCATION:

Institution	Dates	Degree (Subject)
Purdue University	1967-70	Ph.D. (Statistics)
Purdue University	1965-67	M.S. (Statistics)
St. Louis University	1961-65	B.S. (Mathematics)

ACADEMIC EXPERIENCE:

Institution	Dates	Rank
New Mexico State University	1970-75	Assistant Professor
Stanford University	1974, 75 Summers	Visiting Assistant Professor
Arizona State University	1975-1984	Associate Professor
Arizona State University	1984-Present	Professor

GRANTS:

Institution (Employer)	Dates	Topic
ASU Faculty Grant-in-Aid	1976-Summer	Multivariate Analysis
ASU Faculty Grant-in-Aid	1977-Summer	Linear Nearest Neighbor Statistic
ASU Faculty Grant-in-Aid	1980-Summer	Monotone Processes
ASU Faculty Grant-in-Aid	1981-Summer	Goodness of Fit Test
Department of Energy (Co-Principal Investigator)	1981-83	Quantification of Ecological Responses to Perturbations
Intel Corp.	1987-92	Internship in Statistics

EXTERNAL CONSULTING EXPERIENCE:

Institution (Employer)	Dates	Topic
Arizona Attorney General's Office	1980,82,83,87,98	Pyramid Schemes
Arizona Blood Services	1981	ALT Levels
Motorola	1983-1996	IC Data Analysis

ADMINISTRATIVE EXPERIENCE:

Associate Chair, Director of Graduate Studies, Department of Mathematics, 1991-1995
Director of the Committee on Statistics, 1996-present

AWARDS, SCHOLARSHIPS, HONOR SOCIETIES:

NASA Fellowship—Purdue University 1965-68
Arizona Chapter of the American Statistical Association: Outstanding Member Award
1989
ASU Department of Mathematics Wexler Teaching Award 1991

SELECTED PUBLICATION:

Initial attitude differences among successful, procrastinating and withdraw-from-course students in a personalized system of statistics instruction (with F.L. Newman, et al), *Journal for Research in Mathematics Education* 5: 105-13 (1974).

A personalized system of instruction in an undergraduate mathematics service sequence (with H.E. McKean and F.L. Newman), *American Mathematical Monthly* 81: 767-75 (1974).

Linear nearest neighbor analysis (with B.L. Stark), *American Antiquity* 46: 284-300 (1981).

The linear nearest neighbor statistic, *Biometrika* 69: 477-80 (1983).
Formative period political differentiation in the southern valley of Mexico: a comment on Steponaitis (with N.W. Ackerly), *American Anthropologist* 86: 976-85 (1984).

Tree-ring variation in western larch (*larix occidentalis*) exposed to sulfur dioxide emissions (with C.A. Fox, W. Kincaid, T. Nash, H. Fritts), *Canadian Journal of Forest Research* 16: 283-92 (1986).

Application of statistical design and response surface methods to computer-aided VLSI device design (with A. Alvarez, B. Abdi, H. Weed, J. Teplik, E. Herald), *IEEE CAD/CAS* 7: 272-228 (1988).

Application of statistical design and response surface methods to computer-aided VLSI device design II: desirability functions and Taguchi methods (with J. Teplik, H. Weed, N. Tracht and T. Alvarez), *IEEE Transactions on Computer-Aided Design* 10: 103-115 (1991).

Grandparent strengths and need inventory (with P. Collinsworth, R. Strom and S. Strom), *Educational and Psychological Measurement* 51: 785-792 (1991).

Validating the probability of paternity (with D. Kaye, T. Vyvial), *Transfusion* 31: 823-828 (1991).

Weight gain in captive chimpanzee infants: comparisons by sex, rearing and

colony (with M. Marzke and J. Fritz), American Journal of Primatology 38: 133-144 (1996).

Comparative analysis of weight gain, hand/wrist maturation and dental emergence rates in chimpanzees aged 0-24 months from varying captive environments (with M. Marzke, D. Hawkey, S. Su, J. Fritz, P. Alford), American Journal of Physical Anthropology 99: 175-190 (1996).

MASTERS STUDENTS

- M. Salami (1987), Power transformations in analysis of variance.
- Y. Pang (1988), A comparison of tests for equality of two covariance matrices using robust estimates.
- F.K. Wang (1990), Confidence intervals for the mean after a fitted power transformation.
- H. Shahriari (1991), Multivariate tests of normality based on angles.
- R. Aultman (1992), Analogues of the Kolmogorov-Smirnov and Cramer-Von Mises tests for the K sample problem.
- S. Schulze (1992), On tests of symmetry about an unknown center.
- S. Su (1993), Nonparametric modeling and comparison of chimpanzee growth curves.
- F. Schineller (1994), High breakdown local regression smoothing.
- J. Hui (1996), Robust analysis of variance: High breakdown F tests in the one-way ANOVA model.
- K. Stout (1997), Comparison of tests for heteroscedasticity in multiple linear regression analysis

DOCTORAL STUDENTS

K. Hong (1998), Robust Multivariate Analysis: Principal Components Analysis and Discriminant Analysis.

MICHELLE J. ZANDIEH
Department of Mathematics
Arizona State University

EDUCATION

August 1997

Ph.D. in Mathematics, Oregon State University, Corvallis, OR.

Research option in Mathematics Education.

Thesis title: The Evolution of Student Understanding of the Concept of Derivative.

Thesis advisor: Dr. Thomas P. Dick.

June 1989

M.S. in Mathematics, Oregon State University, Corvallis, OR.

Teaching emphasis.

Masters paper title: Applications of Projective Geometry to Computer Graphics.

Paper advisor: Dr. Thomas P. Dick.

June 1987

B.A. in Mathematics and Geology, Northwestern University, Evanston, IL.
Honors in Geology.

Professional Employment

9/97-present

Assistant Professor, Department of Mathematics, Arizona State University, Tempe, AZ.

9/95-8/97

Visiting Lecturer, Department of Mathematical and Computer Sciences, Loyola University of Chicago, Chicago, IL.

Nominated for Sujack Award for excellent teaching.

9/94-5/95

Part-time Instructor, Department of Mathematical and Computer Sciences, Loyola University of Chicago, Chicago, IL.

9/94-5/95

Part-time Instructor, Department of Mathematical Sciences, Roosevelt University, Chicago, IL.

6/92-9/94

Graduate Research Assistant, Department of Mathematics, Oregon State University, Corvallis, OR. Supervisor: Dr. Thomas P. Dick.

Calculus Connection Project Staff: curriculum development, in-service workshops for teachers, research on student understanding of derivative.

9/87-6/92

Graduate Teaching Assistant, Department of Mathematics, Oregon State University, Corvallis, OR.

Mathematics Department Graduate Student Teaching Award for excellent teaching.

Grants

1. PI: Student Understanding of Differential Equations. Faculty Grant in Aid (FGIA) through the Vice Provost for Research. 1/1/98-12/31/98. \$7000.
2. Co-PI: A Redefinition and Reform of a Preservice Secondary Mathematics Curriculum. \$49,500. 4/1/98-3/31/99. Arizona Board of Regents, Eisenhower Math and

Science Program.

Publications

1. Zandieh, M. (1994) "Student Understanding of the Concept of Derivative in a Technology Enhanced Classroom." Proceedings of the Sixteenth Annual Meeting of PME-NA, Vol. 1, (North American Chapter of the International Group for the Psychology of Mathematics Education), p. 125.
2. Zandieh, M. (1997). The evolution of student understanding of the concept of derivative. (Doctoral dissertation, Oregon State University, 1997.)
3. Zandieh, M. (1998) "The role of a formal definition in nine students' concept image of derivative." Proceedings of the Twentieth Annual Meeting of PME-NA, (North American Chapter of the International Group for the Psychology of Mathematics Education) (November 1998.)
4. Zandieh, M. "A theoretical framework for analyzing student understanding of the concept of derivative." (Submitted July 1998.)
5. Zandieh, M. "Developing an understanding of the concept of derivative: The case of Ingrid." (To be submitted.)

Selected Professional Presentations

"Student Understanding of the Concept of Derivative in a Technology Enhanced Classroom." Sixteenth Annual Meeting of PME-NA, (North American Chapter of the International Group for the Psychology of Mathematics Education), November 1994.

"Student Understanding of the Concept of Derivative in a Technology Enhanced Classroom." Seventh Annual International Conference on Technology in Collegiate Mathematics, Orlando, FL, November 1994.

"An Introduction to the HP38G." San Jacinto College Conference on Technology, Houston, TX, July 1995.

"Data Analysis Using Aplets and the HP38G." Eighth Annual International Conference on Technology in Collegiate Mathematics, Houston, TX, November 1995.

"Student Understanding of Derivatives: Multiple Representations, Technology, Connections and Misconceptions." Eighth Annual International Conference on Technology in Collegiate Mathematics, Houston, TX, November 1995.

"The Concept of Derivative: A Variety of Understandings." Ninth Annual International

Conference on Technology in Collegiate Mathematics, Reno, NV, November 1996.

"What is the Role of the Definition in a Student's Understanding of the Concept of Derivative?" Research Conference in Collegiate Mathematics Education - Central Michigan University, Mount Pleasant, MI, September 1997.

"The role of derivative in student understanding of differential equations." Research Conference in Collegiate Mathematics Education – South Bend, IN, September 1998.

"The role of a formal definition in nine students' concept image of derivative."
Twentieth Annual Meeting of PME-NA, (North American Chapter of the International Group for the Psychology of Mathematics Education), November 1998.
APPENDIX: Sample Programs of Study

Sample Program

Concentration in Mathematics Education emphasis in middle grades mathematics

CORE REQUIREMENTS (total of 6 hours)

DCI 701 Curriculum Theory and Practice
DCI 791 Interdisciplinary Research Seminar

PROFESSIONAL FOCUS

Inquiry and analysis (15 hours)

COE 503 Introduction to qualitative research in education
EDP 552 Quantitative data analysis in education 1
EDP 552 Intermediate statistical data analysis in education
EDP 556 Data processing techniques in measurement and research
EDP 651 Methods and practices of qualitative research

Major area of concentration (27 hours)

EED 537 Mathematics in the elementary school
EED/SED 594 Mathematics in the middle school
EED/SED 791 Research in mathematics education 1
EED/SED 791 Research in mathematics education 2
EED 598 Children's mathematical thinking

BLE 598 Teaching mathematics for Spanish speakers
MAT 598 Research in undergraduate mathematics education 1
MTE 585 Modern geometry for teachers
EED 598 Teaching geometry K- 8

Internship (6 hours)

EED/SED 784 Internship in teaching mathematics
EED/SED 784 Internship in research in mathematics education

COGNATE STUDY (12 hours)

EMC 598 Technology in teaching and learning of mathematics
EMC 598 Internet for teachers
EED/SED 598 Integrated mathematics, science and technology
EMC 528 Advanced web production

DISSERTATION AND INDEPENDENT RESEARCH (a total of 24 hours)

EED/SED 792 Research
EED/SED 799 Dissertation
Sample Program

Concentration in Mathematics Education emphasis in secondary mathematics

CORE REQUIREMENTS (total of 6 hours)

DCI 701 Curriculum Theory and Practice
DCI 791 Interdisciplinary Research Seminar

PROFESSIONAL FOCUS

Inquiry and analysis (15 hours)

COE 503 Introduction to qualitative research in education
STP 530 Applied regression analysis
STP 531 Applied analysis of variance
STP 533 Applied multivariate analysis
EDP 651 Methods and practices of qualitative research

Major area of concentration (27 hours)

MAT 598 Research in undergraduate mathematics education 1
MAT 598 Research in undergraduate mathematics education 2
MAT 598 Research in undergraduate mathematics education 3
EED/SED 791 Research in mathematics education 1
EED/SED 791 Research in mathematics education 2

SED/EED 594 Integrated mathematics, science, and technology

EED/SED 594 Mathematics in the middle school
MAT 472 Intermediate real analysis
MAT 444 Intermediate abstract algebra

Internship (6 hours)

EED/SED 784 Internship in teaching mathematics
EED/SED 784 Internship in research in mathematics education

COGNATE STUDY (12 hours)

MAT 442 Advanced linear algebra
STP 421 Probability
MAT 543 Abstract algebra
MAT 570 Real analysis

DISSERTATION AND INDEPENDENT RESEARCH (a total of 24 hours)

EED/SED 792 Research
EED/SED 799 Dissertation
Sample Program

Concentration in Mathematics Education emphasis in College Mathematics

CORE REQUIREMENTS (total of 6 hours)

DCI 701 Curriculum Theory and Practice
DCI 791 Interdisciplinary Research Seminar

PROFESSIONAL FOCUS

Inquiry and analysis (15 hours)

COE 503 Introduction to qualitative research in education
EDP 552 Quantitative data analysis in education 1
STP 530 Applied regression analysis
STP 531 Applied analysis of variance
STP 533 Applied multivariate analysis

Major area of concentration (27 hours)

EED/SED 791 Research in mathematics education 1
MAT 598 Research in undergraduate mathematics education 1
MAT 598 Research in undergraduate mathematics education 2
MAT 598 Research in undergraduate mathematics education 3

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